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# THREE NEW DEVICES FOR MEASURING INSECT POPULATIONS

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The devices described below were developed in connection with field studies of the beet leafhopper (Eutettix tenellus (Baker)). These studies required rapid and reasonably accurate estimates of populations of a very active insect under a wide variety of weather and host-plant conditions. All three of the methods described give reasonably comparable results in the field insofar as can be determined and are independent of weather conditions at temperatures above the insect's threshold of activity.

Each of the three devices was designed to sample a different type of vegetation. The sampling pan can be used on low-growing plants a few inches in height and is particularly suitable for sampling a dense, low ground cover, such as that formed by a lawn. The fork was made to sample stands of plants which grow close together with most of their foliage an inch or more above the ground. Thick, tall grass would be such a stand. The spear was designed to sample large plants with nearly all the branches off the ground, such as shrubs and small trees.

In principle the sampling pan is a container which is put down over the plants to be sampled in order to confine the insects which are on these plants. The pan differs from other devices of the same type in that provision is made for trapping active insects to facilitate counting.

The fork and spear are alike in principle. They capture a small sample of definite size from a larger number of insects as they are killed on the plants and fall to the ground. The killing is done with some suitable contact insecticide. In beet leafhopper studies a kerosene-pyrethrum mixture has been found most satisfactory. A reliable hand-operated compressed-air sprayer is a necessity in using the fork and spear and for certain types of sampling with the pan. This sprayer should be of the type which can be pumped up before any spray is released and which will hold a sufficient head of air to release spray under considerable pressure for a period of at least half a minute without additional pumping.

## THE SAMPLING PAN

### Construction

The sampling pan is illustrated in figure 1. It is essentially a round metal can with a large hole in the bottom. It is made of sheet metal about 24 pounds in weight. Black metal has been used, since the beet leafhopper is generally a light-colored insect and is seen more easily against a dark background. The pan shown samples a 1/2-square-foot area. Except for the size of the hole in the bottom when a sampling area of definite size is desired, there is nothing narrowly fixed about the dimensions. The width of the ledge can be determined by convenience. The height of the pan should be such that insects jumping from the top of plants will not be able to clear the top of the pan.

The bottom or ledge of the pan should be made of about 14-pound sheet metal to prevent bending with hard usage. The taper of this ledge makes it possible to force the cutter into the soil until the inner edge of the pan rests on the surface, even when the soil surface is rough or when small stones or sticks interfere. The cutter should be made of a good grade of steel that will hold a relatively sharp edge. All inside joints in the pan should be smooth, and, to facilitate cleaning, it is best to round the angle where the ledge joins the sides. The upper edge is strengthened and smoothed by a double hem rolled outward.

### Use

The inside of the pan is covered with a film of light oil, such as kerosene, usually a kerosene-pyrethrum insecticide applied with a spray gun. The pan is then set down firmly and quickly over the plants to be sampled. Upon striking the ground it is pushed downward and twisted in such a manner as to force the cutter through the plants and into the soil until the inner edge of the ledge rests on the soil surface. After the pan is in place any insects contained in the 1/2-square-foot area are disturbed with the hand or by means of a liquid spray discharged from the spray gun into the sampled area. This causes the insects to jump onto the sides of the pan or onto the ledge, where they become stuck. They can then be readily counted. Insects seldom become stuck to the plant, probably because the oil does not form a continuous film on the surface as it does on the metal surface of the pan.

A much smaller pan, constructed of lighter material, with a 1/4-inch rim substituted for the cutting edge, which is not needed on so light a pan, and a central opening 1/8 square foot in area, has been found useful in counting very small nymphs. In a sparse stand of short host plants the population of first instars of the beet leafhopper can be counted with this device.

Under the conditions encountered in beet leafhopper studies, adults and small nymphs usually cannot be counted in the same sample because a spray is necessary to prevent the escape of adults but cannot be used with nymphs because it kills many of them before their erratic jumps land them on the ledge where they can be seen. Consequently it is better to disturb the plants with the hand, driving the nymphs onto the ledge without using spray, except as a sticker on the inside of the pan. Ordinarily even this is not necessary, as nymphs can be killed or captured as they are counted. When adults are sprayed they nearly always become stuck on the ledge or sides of the pan. Under ordinary conditions, if the spray is applied downward into the pan very quickly after it is set in place, the force of the spray knocks the insects down and very few escape. If adults are very active, a screen lid can be hinged to the pan to prevent escapes.

## THE SAMPLING SPEAR

### Construction

This instrument, illustrated in figure 2, is merely a flat triangular metal plate with a wooden handle of convenient length. It is made of sheet metal about 28 pounds in weight, which is light enough to be flexible but strong enough to prevent excessive bending. The dimensions of the spear for any desired angle or area can be found from the following formula:

If $a$ = altitude of triangle or length of spear in inches

$b$ = base of triangle or width of spear in inches

$A$ = area of spear in square inches

$x$ = angle in degrees

Then $a = \frac{A}{\tan \frac{x}{2}}$ and $b = \frac{2A}{a}$

### Use

In using the spear the metal plate is covered with a film of oil spray and placed under the plant to be sampled. The plant is then sprayed to kill the insects which are on it and cause them to drop off onto the ground. Some of them drop on the metal plate and stick in the oil. It is essential that an area of the plant considerably larger than the spear itself be sprayed, particularly if a wind is blowing. This must be done to make sure that the wind does not blow the sprayed insects over and beyond the spear. When insects are hit by the spray material, they move erratically in all directions before they die, and in theory the spear takes a random sample of these insects. This sample is a sort of average

of a much larger area than the actual area of the spear itself. There is a tendency for insects falling on the ground near the spear to jump erratically and sometimes become stuck. This is partly counterbalanced by escapes. However, to reduce this error still further, a border which is not considered is left around the 1/2-square-foot counting area of the spear.

In sampling a small plant the radius of which is less than the length of the spear, the point of the apparatus is inserted under the plant until near the center, and the spray is applied to the whole plant. All insects caught on the spear within the marked angle are considered as coming from the segment of a circle with the same angle. That is, on the spear shown in figure 2 the sample would consist of one-tenth of a circle or one-tenth of a plant, and populations are estimated on a per-plant basis.

A small series of collections made with spears of 1/4-, 1/2-, and 1-square-foot areas indicate that the three sizes give results in proportion to the size of the spear.

This instrument has been found satisfactory for sampling both nymphs and adults of the beet leafhopper.

## THE SAMPLING FORK

This device, as illustrated in figure 3, is made up of six tines, each 1 inch in width, attached to a metal base at intervals of 1 inch. A handle of convenient length is bolted to this base. The tines and base are cut from heavy sheet metal about 1/16 inch in thickness. Metal of this weight gives the necessary strength to the tines but still allows a sufficient amount of flexibility for proper manipulation. The tips of the tines are cut to a point and curved slightly upward so that they will slip between the plant stems without digging into the soil when the fork is placed under the plants. The fork shown in figure 3 has a sampling area of 1/2 square foot consisting of six tines, each 1 inch wide and 12 inches long. The base and points of the tines are not counted.

### Use

The sampling fork is used in exactly the same way as the spear, except that the design shown in figure 3 cannot be employed to take a segment of a circular sampling area. It probably could be used for this purpose if made in the shape of a triangle. The fork can be used on a dense growth of plants whose stalks grow too close together to allow the spear to be placed under them. Under these conditions it is advisable to apply the spray to the plants very quickly after the fork is in place to prevent the disturbed insects from leaving the sampling area.

Like the spear, the fork is subject to some error due to the tendency of insects to stick on the spear rather than on the

ground. With the fork, however, this error is apparently counterbalanced by the greater tendency to escape from the narrow tines.

## COMPARATIVE ACCURACY OF METHODS

To determine the comparative accuracy of these methods, a series of comparable collections were taken with the fork, pan, spear, and Hills' sampler 1/ in California and southern Idaho. The California series of counts comparing the spear and Hills' sampler were taken on a perennial shrub, Lepidospartum squamatum A. Gray The southern Idaho collections were made on flixweed (Sophia parviflora (Lam.) Standl.) and on Russian-thistle (Salsola pestifer A. Nels.). The flixweed on which collections were made grew approximately 1 foot high and formed a rather dense stand with the stalks close together. Russian-thistle in the 1933 collections formed a dense stand 6 to 12 inches in height. The 1940 collections were made on widely spaced plants 2 to 4 feet in height. The results of these comparisons are given in table 1.

No significant differences were noted in these collections except in comparisons of nymphal populations on the fork and spear. However, fork collections were consistently higher than either those of the pan or Hills' sampler. This difference is probably due to the fact that some insects are always missed in counting and a few escape in the pan and Hills' sampler. In Idaho the fork and spear collected about the same number of adults, but the fork collected a significantly higher number of nymphs than the spear. In these counts the spear could not always be placed directly under the plants, while the fork went under easily. Since nymphs which are hit with the spray tend to fall directly down, they were not caught on that portion of the spear which was not under the plant, and this introduced an error into the counts. Adults tend to spread more widely and were caught on all portions of the spear, so the error was smaller. This illustrates the necessity of proper placement of these devices and the use of the method best suited to the vegetation to be sampled. It also suggests that there is an error in the relative proportions of nymphs and adults caught by these two methods.

None of these devices is suitable for all-purpose collecting and none is a measure of absolute numbers. However, assuming that under ideal conditions Hills' sampler gives an approximately correct count of adults and the sampling pan a similar measure of nymphs, the data given indicate that the maximum error of any of the methods is not more than 30 percent. This is not excessive for estimates of insect populations in the field.

The principal advantages of these methods are that they give a rapid estimate of populations and are reasonably independent of weather conditions and types of vegetation.

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1/ Hills, O. A. A new method for collecting samples of insect populations. Jour. Econ. Ent. 26: 906-910. 1933.

Table 1.--Comparative beet leafhopper counts by various methods

| Date | Host plant | Type of leafhoppers | Sampling method | Area of each sample (Sq. ft.) | Samples (Number) | Mean leafhoppers per sq. ft. (Number) | Difference (Number) | Difference required for significance (Number) |
|---|---|---|---|---|---|---|---|---|
| 1933 | | | | | | | | |
| June 5 | Flixweed | Nymphs | Pan 7" high | 0.5 | 30 | 5.2 | 1.5334 | 2.2544 |
| | | | Pan 12" high | .5 | 30 | 3.6666 | | |
| June 5 | Flixweed | Nymphs | Fork | .5 | 115 | 7.3738 | .8108 | 1.5864 |
| | | | Pan | .5 | 135 | 6.5630 | | |
| June 6 | Flixweed | Adults | Fork | .5 | 40 | 1.65 | .675 | .8624 |
| | | | Hills' sampler | 1.0 | 40 | .975 | | |
| August 4 | Russian-thistle | Nymphs | Fork | .5 | 60 | 9.4334 | 2.1334 | 2.3159 |
| | | | Pan | .5 | 60 | 7.3000 | | |
| August 4 | Russian-thistle | Adult females | Fork | .5 | 60 | 1.3 | .0167 | .5372 |
| | | | Hills' sampler | 1.0 | 60 | 1.2833 | | |
| August 4 | Russian-thistle | Adult males | Fork | .5 | 60 | 1.9333 | .5833 | .6399 |
| | | | Hills' sampler | 1.0 | 60 | 1.35 | | |
| October-November 1940 | Lepidospartum | Adults | Spear | 2.5 | 14 1/ | 2.4 | .1714 | 1.0245 |
| | | | Hills' sampler | 5.0 | 14 2/ | 2.2286 | | |
| Sept. 25 | Russian-thistle | Adults | Spear | .5 | 26 | 28.7692 | 1.4616 | 4.7124 |
| | | | Fork | .5 | 26 | 30.2308 | | |
| Sept. 25 | Russian-thistle | Nymphs | Spear | .5 | 26 | 43.3076 | 17.3078 | 10.0744 |
| | | | Fork | .5 | 26 | 60.6154 | | |

1/ Each sample is the sum of five 0.5-sq.-ft. counts.
2/ Each sample is the sum of five 1.0-sq.-ft. counts.

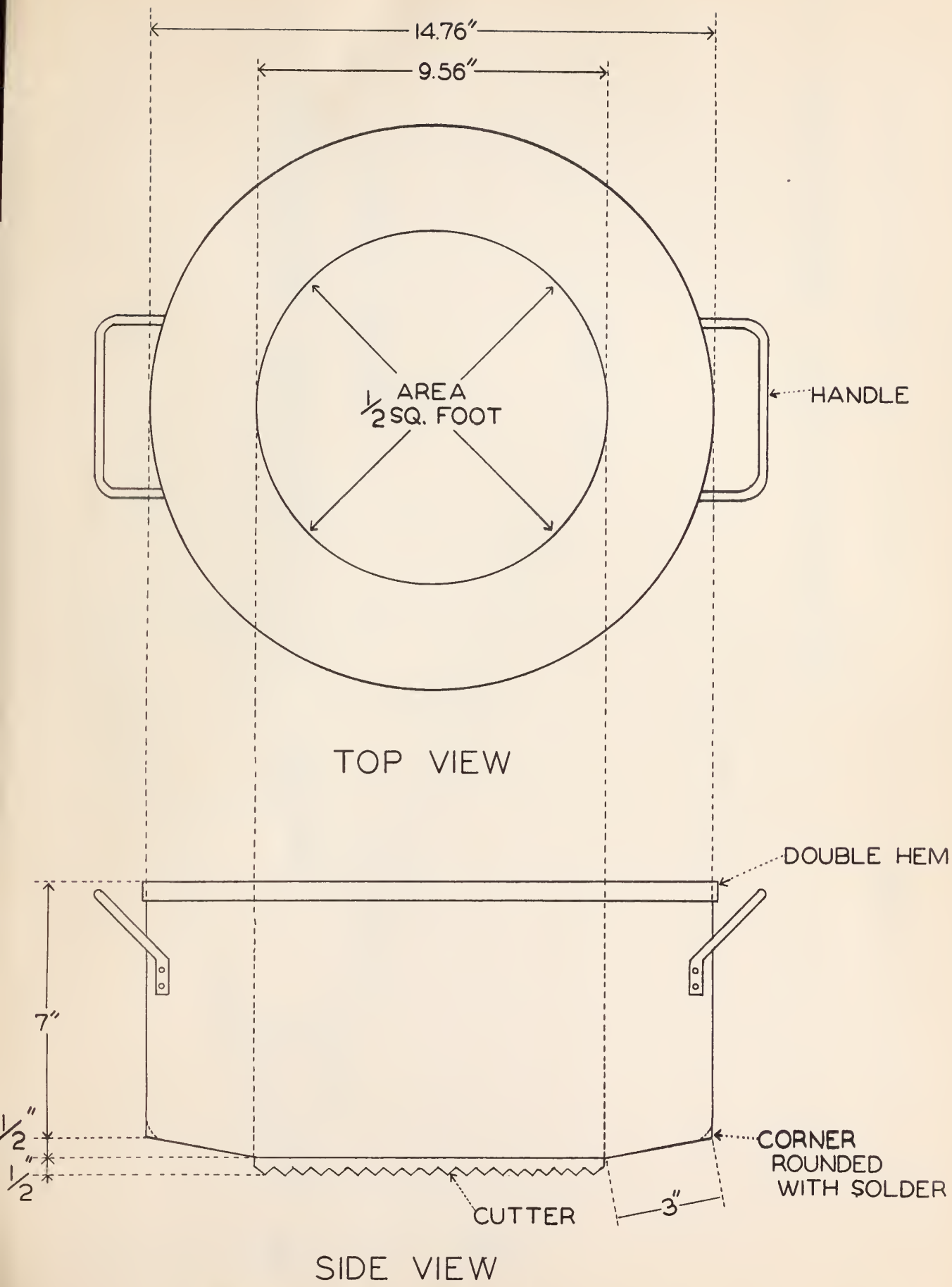


**Figure 1.--Detail drawing of the sampling pan.**

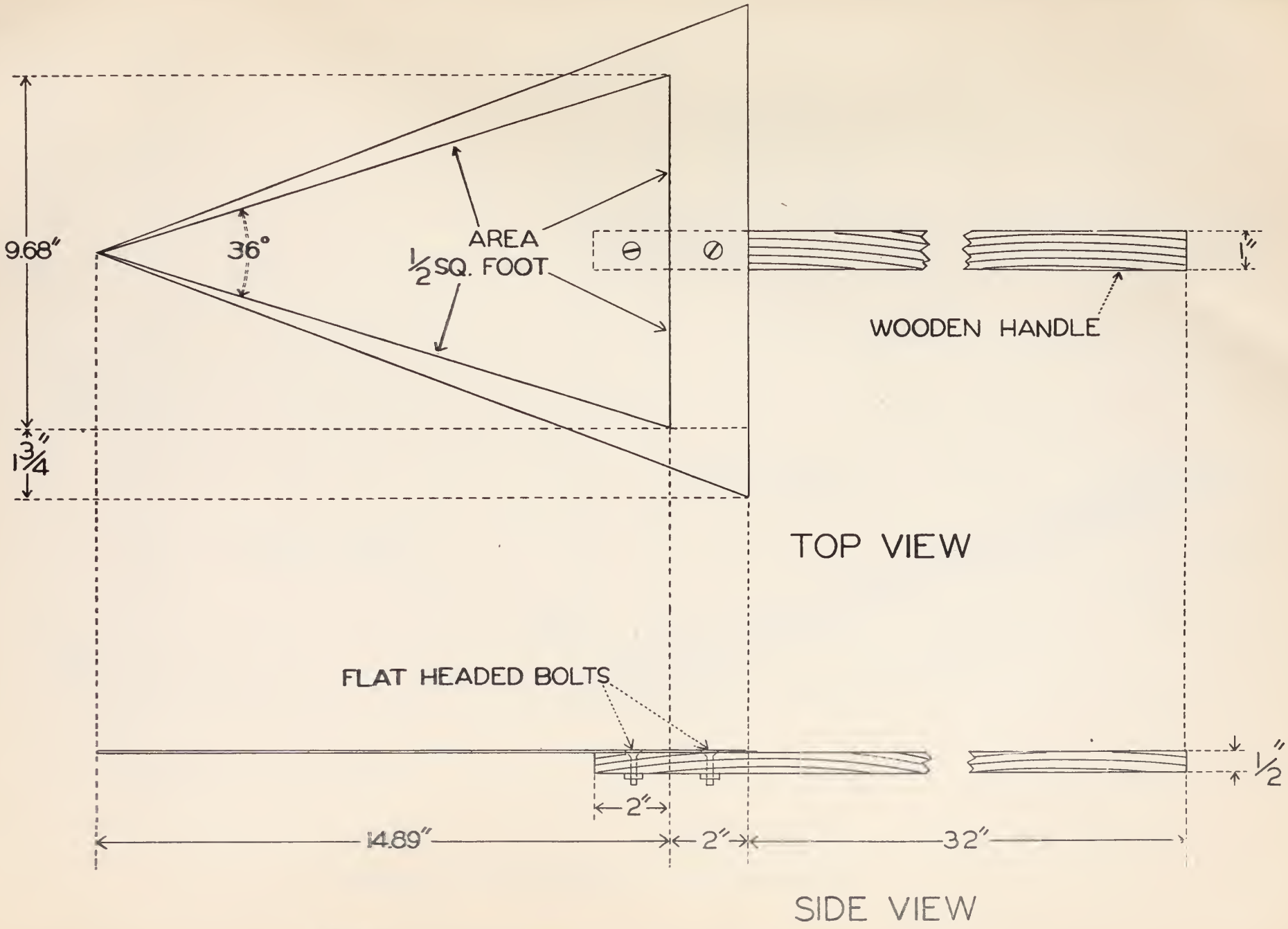


Figure 2.—Detail drawing of the sampling spear.

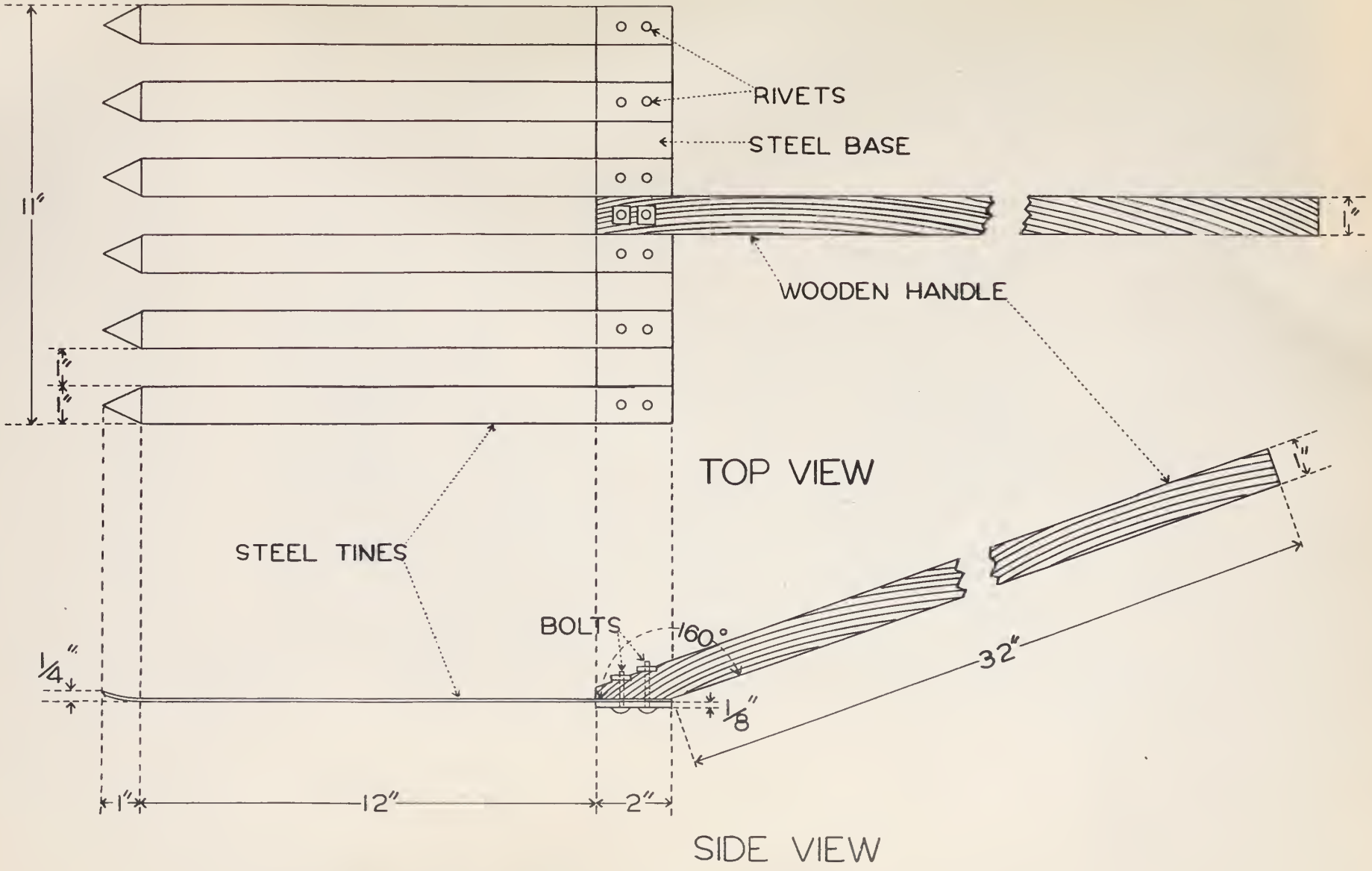


Figure 3.—Detail drawing of the sampling fork.